

Task scheduling algorithm using grey wolf optimization technique in cloud computing environment

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ABSTRACT

Scheduling refers to the process of allocating cloud resources to several users according to a schedule that has been established in advance. It is not possible to get acceptable performance in settings that are distributed without proper planning for simultaneous processes. When developing productive schedules in the cloud, it is necessary for work scheduling to take a variety of constraints and goals into consideration. When dealing with activities that have performance optimization limits, resource allocation is a very important aspect to consider. When it comes to cloud computing, the only way to achieve great performance, high profits, high scalability, efficient provisioning, and cost savings is with an exceptional task scheduling system. This article presents a grey wolf optimization (GWO) based framework for efficient task scheduling in cloud computing environment. The proposed algorithm is compared with particle swarm optimization (PSO) and flower pollination algorithm (FPA) and GWO is performing task scheduling in less execution time and cost in comparison with PSO and FPA techniques. Execution time taken by GWO to finish 200 task in 120.2 ms. It is less than the time taken by PSO and FPA algorithm to finish same number of tasks.

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1. INTRODUCTION

As a result of recent developments in cloud computing, it is now possible to provide dynamic services on a large scale through the internet at much reduced prices and with improved scalability. This is not just possible but practical thanks to cloud computing. Memory, data storage, and bandwidth on a network are just a few examples of the resources that may be made more easily available via the use of cloud computing. These, along with a large number of other resources, are among those that may be configured.

The cloud's resources may be used at the same time by a very large number of users, and they can be redistributed in response to variations in the amount of demand [1].

Users are only charged for the resources that they really make use of while working in the cloud. Users are able to access cloud-based services and applications from any computer or mobile device so long as the device in question maintains a functional internet connection. Cloud computing is designed in such a way that the user does not need to be concerned with maintaining the resources or identifying the extent of those resources while they are being used. The availability of resources is becoming an increasingly pressing issue for users of cloud computing. To satisfy the requirements and requirements of end users, it is necessary to make the most efficient use of the resources that are already available. To achieve this goal, one strategy that might be used is one that is well planned out about time management. As the number of people who use the cloud continues to rise, it becomes more difficult for cloud service providers to ensure that cloud resources are being used efficiently. As a direct result of this issue, work scheduling difficulties will inevitably emerge and need to be addressed. It is vital to build a more efficient positioning and structure in order to maximize the benefits that may be gained from using the cloud computing. Because virtual machines (VMs) have such a significant influence on the way cloud resources are planned, it is crucial that they be accounted for in the schedule. As a consequence of this, it is essential that each VM inside a certain virtual environment be kept separate from all of the other VMs found within that environment. The requirements for a VM's processor, memory, and bandwidth are all determined by the host computer on which the VM is running. Scheduling [2], [3] refers to the process of allocating cloud resources to a large number of users in accordance with a predetermined timetable that has been created in advance. Accomplishing high performance in a distributed environment requires careful planning of simultaneous operations in order to be successful. In order to be effective, the scheduling of work in a cloud environment has to take a number of different restrictions and goals into account. For example, task mapping is an example of an NP-hard problem since it is difficult to solve given the resources that are currently available. It is necessary to find a solution to the problem of quality of service (QoS) [4] before cloud computing can be considered a success.

It is necessary for there to be compatibility between the user's needs and those of the cloud service provider in terms of the scheduling criteria. At no point can the user's timeline, money, or security be put at risk, nor can their deadlines be ignored. limits imposed by cloud service providers, such as increasing the number of tasks successfully finished and optimizing resource usage while simultaneously maximizing the advantages obtained. Each and every scheduling algorithm has to take into consideration these requirements before it can schedule an application or a job. Jobs, also known as activities needing computing, are managed in the same manner as user applications. In order to successfully complete the project, the whole work will first need to be segmented into a number of more manageable jobs. To phrase it another way, tasks are the smallest possible units of computation that may be carried out using a certain resource. An individual task is considered to be a single computing unit that cannot be broken down into smaller pieces. This means that individual jobs cannot be divided into smaller jobs. If we use instructions that are not preemptible, we will be able to create a task that is capable of running on any resource or node in the system. There are a variety of approaches that may be used in order to finish the job. The next essential component of a scheduling strategy are the optimization criteria, and they are quite important in their own right. Even if the user does not designate a date or budget for the project, it is still possible for it to be finished more swiftly and securely. Putting optimization criteria to use may be of use here. Before developing a scheduling algorithm, cloud service providers and their clients should first get familiar with any limitations or optimization criteria that have been established by research and development [5].

The cloud provider is responsible for dynamically adding and removing resources from the cloud environment. This is one of the obligations that they have. It is possible to hand in assignments at any moment if they are given according to the convenience of the user or according to the availability of the resources. Cloud virtualization is an essential need for cloud clients since it gives them the ability to access and make use of cloud resources whenever they require them [6].

The findings shown in Figure 1 imply that task scheduling should be included into the design of any cloud computing system if the system is to effectively manage resources and provide support to users of the cloud. When it comes to the optimization of performance for tasks that have restrictions, the distribution of resources is an extremely important factor. Work scheduling in cloud computing is the only way that can meet vital goals such as high performance, high profit, high utilization of resources, scalability, provision efficiency, and economy.

When work schedules don't always remain the same, you need to have management and capacity in place in order to discover the VM resources that are the most effective. Operations that are carried out inside a cloud framework include a wide range of QoS concerns. Users of cloud computing services are able to complete their job inside the simulated setting offered by the VM. On a single server, many VMs, may be generated depending on the amount of resources required to successfully execute the operating system and the settings [7].

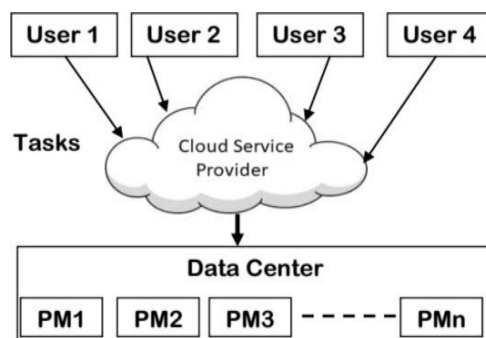


Figure 1. Task scheduling in cloud computing

A user of the cloud framework will first need to submit a job to the task scheduler module before the process of finding a VM that is suitable for a particular undertaking can begin. When it comes to allocating basic or high demanding tasks to the proper VM, there is a lot of potential for mistake when using VMs. It is possible that the overall performance of the system will suffer as a result of the lengthier wait periods as well as the longer MakeSpan. When seen from the perspective of the cloud provider, there is a decline not just in the total throughput but also in the profit. When using a cloud platform, meeting highQoS criteria will require you to wait longer and pay a higher price for the service. Because of this, the satisfaction of the customers will decrease [8].

If cloud service providers and their customers are going to be happy with the cloud, then the algorithms that are used to schedule work need to be improved. The approach to scheduling that makes the best use of both time and money is the one that enables tasks to be delegated to the VM resources that are best suited to perform those tasks while using the smallest possible amount of both resources. Scheduling algorithms need to be able to achieve QoS requirements like makespan and resource utilization while still maintaining a low cost.

This article presents a grey wolf optimization (GWO) based framework for efficient task scheduling in cloud computing environment. The proposed algorithm is compared with particle swarm optimization (PSO) and flower pollination algorithm (FPA) and GWO is performing task scheduling in less execution time and cost in comparison with PSO and FPA techniques.

2. LITERATURE SURVEY

Task scheduling is regarded as an NP-hard problem because of how difficult it is to accurately estimate the amount of time that will be necessary to finish a job [9]. Traditional approaches provide better results when both the population size and the time limits are present, despite the fact that neither of these factors can be changed. Incomplete or erroneous data, in addition to a lack of available resources, are common factors that might make optimization difficult. When trying to solve optimization problems, utilising meta-heuristics may include using a random selection in conjunction with the search for the most optimal probable response.

According to the definition given in [10], meta-algorithms are “higher level” algorithms that, in comparison to standard algorithms and fundamental heuristics, provide more accurate results. Techniques such as randomization and local search are often used during the development of these algorithms. Utilizing the randomization process in order to broaden the scope of the search from local to global is a strategy that has a chance of yielding positive results and should be considered. Any combination of meta-heuristic algorithms, which are capable of being used for computation as well as global optimization, may be applied, and it is viable to do so. Meta-heuristic algorithms are superior to other approaches when it comes to dealing with combinatorial optimization issues. This is due to the fact that meta-heuristic algorithms are able to search through a wider variety of potential solutions than other methods.

Research on combinatorial optimization is now focusing a lot of attention on meta-heuristic algorithms, which are computer program that take their cues on how to solve problems from the natural world. These methodologies have demonstrated to be superior when used to high-dimensional nonlinear optimization problems. According to Kaur *et al.* [11], it is useful because it is able to employ all of the population’s knowledge in the process of solving NP-hard issues like task-resource allocations and other optimization problems. This capacity is what gives it its unique selling point.

The updated PSO technique for task scheduling used the one-to-one mapping and the fastest processor to reduce the makespan. This was done in order to save as much time as possible. For this reason, the jobs that required the maximum amount of time were given to the processors that were the most efficient. When the project's scope is increased, the proposed solution will need more time and effort to accomplish in comparison to PSO or the genetic algorithm [12].

Sa'ad *et al.* [13] was the one who came up with the discrete symbiotic organism search approach. Those individuals whose jobs are performed in the cloud will find this strategy to be very helpful. Relationships based on mutualism, commensalism, or even parasitism might be used in order to accomplish the required task. In this research, it was found that the self-adaptive particle swarm optimization had unacceptable lifetimes, degrees of imbalance, and reaction times (SAPSO). However, the total cost of calculation is larger when compared to the expenditures that are incurred by using alternative methods.

Ari *et al.* [14] found a solution to the makespan problem in a dynamic cloud system by adopting a job scheduling approach that was based on ant colony optimization (ACO). The problem was solved by using the natural intelligence of an ant colony as well as its mechanisms of positive reinforcement. It was discovered that First Come First Serve and Round Robin offered little to no advantage in terms of reducing the amount of time it required to do the jobs. Despite this, the remedy that has been suggested does not solve the imbalance and instead may restrict the ability of the system to grow.

One group of researchers looked at how to best organize work schedules by using enhanced particle swarm optimization (LBMPSTO). As a result of this study, a load-balancing task scheduling strategy that includes a mutation process was developed. The findings were equivocal on the question of whether or not the time it takes to accomplish a job can be shortened and whether or not the workload can be distributed fairly across VMs. In addition, it has been shown that the method of distribution has contributed to an increase in the dependability of the product [15].

Chitra *et al.* [16] described an ant colony optimization with particle swarm (ACOPS) as a dynamic load balancing solution for offering customized VM demand facilities while taking into account three resource requirements. This solution was offered in the form of an ant colony optimization with particle swarm. In order to provide a quicker response, this solution incorporates a pre-rejection module. This module makes use of prior workload requests in order to anticipate future workload needs. As a direct consequence of this, both decision-making and reaction times, in addition to the overall performance of the system, are significantly enhanced. If, on the other hand, the author does not take service level agreement into consideration, it is not possible to decline the request.

According to Mohan *et al.* [17], there is a method for scheduling work that makes use of load migration and improved bee colony optimization. The jobs that are moved from VMs that are overloaded may be compared to honey bees, while the jobs that are relocated from VMs that are underloaded can be compared to food. Although the amount of time it takes to do a project as well as the QoS that is provided to customers are both increased as a result of this approach, it is not the best option during times of high demand because of the inability of this technique to scale.

Nabi *et al.* [18] made the suggestion that a PSO heuristic may be implemented through task matching in heterogeneous computing systems. According to the findings of their investigation, this idea was considered. Through the distribution of workloads among a large number of computers, each of which has a unique execution time, it is feasible to shorten the overall makespan of the schedule. At the very end, there is a last-minute adjustment made to the schedule for the machines that are still operating. The number of iterations will be cut short after the makespan has been brought down to the point where it can no longer be brought down any more. When compared to the procedures that are presently being utilized, these tests demonstrate a reduction in the amount of time required as well as a more efficient use of the resources that are now accessible.

PSO is used for searching in the hybrid approach devised by [19], while cuckoo search is used for population creation. PSO is used to search for optimal solutions. The problem with the inertia weight that the original PSO had may be helped by local search. The results of the simulation reveal considerable time and resource savings in addition to improved use of the resources that are already available for the project.

Agarwal and Srivastava [20] outlines a method for cuckoo search-based task scheduling that may be used with cloud computing. By spreading out the work over all of the available virtual computers, it is feasible to cut down on the amount of response time that is required overall. Each VM was given the same amount of processing power, and the results were compared to those obtained by using either the First In First Out or the greedy method for allocating resources to VMs. The suggested method is superior to the alternatives in terms of balancing the load, maximising the use of resources, and reducing reaction times.

Wang and Zuo [21] were able to solve a problem with the scheduling of work on public clouds by making a number of improvements to PSO. In addition to the more common time-based fitness function, the proposed algorithm also includes a fitness function that takes into consideration the pricing of the various resources that are accessible. It is possible that by using this technique, one would be able to cut down on the

amount of time and resources required to devise an optimal answer for the whole world. According to the findings of a number of studies, cloud computing may save costs and cut down on time.

Improved Differential Evolution Algorithm (IDEA) is the name that [22] gave to the new method that they developed for allocating resources and scheduling cloud-based jobs. The problem of exploration and exploitation is attacked head-on by the software via the use of the differential evolution algorithm and Taguchi methodologies. The recommended cost models and execution plans have been developed with the goal of achieving the greatest possible overall performance with regard to both costs and amounts of time. The findings are significant in light of the standard procedures that are now in use.

Shafahi and Yari [23] provide a method for the scheduling of work that takes into account energy consumption in cloud computing. They have devised a one-of-a-kind strategy by combining the concepts of cultural optimization with ant colony optimization. This method seeks to maximize productivity and effectiveness by using strategies that focus on colony and cultural optimization. This approach intends to make the most of the benefits offered by both algorithms while minimizing the drawbacks associated with any one. The fundamental purpose of the method is to do this. During the testing, it was discovered that the suggested method used far less energy than the algorithms that had been used up to this point in time. In cloud computing systems that are dynamic, the strategy is completely worthless because of the static calculating methodology that it uses.

3. METHOD

Customers are able to utilize cloud computing for a variety of purposes, including gaining access to services, storing massive quantities of data, and developing brand-new applications from the ground up. It may be challenging to provide on-demand access to resources while also keeping control over a big number of consumers. It is very necessary for all jobs that are interdependent to have careful planning and management in place in order to make the most of the resources that are now available. Automated work scheduling methods have been created in order to satisfy a variety of goals, including but not limited to the reduction of expenses and the increase in server utilization.

For the purpose of increasing scheduling effectiveness and achieving several goals, including lower execution time, cost, and server utilization, a framework for efficient cloud task scheduling that is based on the PSO, GWO, and FPA is offered. This is done in order to demonstrate the framework. This is done in order to ensure that cloud-based task scheduling is as efficient and effective as possible.

Taking its cues from the natural world, the FPA was developed to simulate the natural process of pollination that takes place in flowering plants. Pollen might travel to its destination on a variety of different vectors, including plants, birds, animals, and the wind. Self-pollination and cross-pollination are the two types of pollination, and the difference between the two is determined by the amount of different pollinators that are present throughout the process. Both biotic pollination and cross-pollination are used in this process in order to broaden the scope of the search. It is possible to demonstrate pollen movement by using a mathematical model known as the Levy flight function [24].

The goal of the GWO algorithm is to simulate the social behavior of a pack of grey wolves as they hunt and consume their prey [25]. The typical size of a grey wolf pack is anything from five to twelve individuals. The behavior of the most powerful people within each pack is what establishes the orderly power structure that exists among wolves. This hierarchy of power is quite rigorous. The pack's secondary and tertiary members, on the other hand, look to the leader, who is the most well-known wolf in the group, for direction. The wolf that is in charge of prey hunting defers to the judgments made by the wolves who are second and third in subordinate status. The GWO algorithm places a significant emphasis on both locating prey and encircling it as two of the most important activities it does.

The PSO method will make advantage of the swarming behavior of many different species, such as fish and birds, as an extra stochastic strategy. This will allow the algorithm to more effectively solve problems. Within the search zone, each particle has its own distinct position and speed, and it is free to go in whatever direction it chooses. To put it another way, the particle can only travel to regions where there are already previous particles that have completed their mission successfully in the past [26]. In addition to this, the particle is directed to the location of any other particles that have already completed their mission without incident. A set of rules that have been applied to the process may account for the speed of each particle as well as its location at any given point in time.

4. RESULT ANALYSIS

The configuration includes both a simulation environment as well as a Java implementation of CloudSim version 3.0.1. Both of these components are part of the set-up. This investigation is being carried

out with the assistance of a datacenter and twenty cloudlets, each of which has four virtual personal computers. As a direct result of this, GWO, PSO, and FPA algorithms could be used in order to enhance the results of the scheduling methodologies. By scheduling the operations in such a way, it is feasible to meet the goals of lowering expenses, completing activities more quickly, and increasing server utilization. Table 1 and Figure 2 provide examples of the amount of time the jobs take to carry out. The expenses are broken out in Table 2 and Figure 3. Experiment has been conducted using different number of tasks such as- 200 tasks, 400 tasks, 600 tasks, 800 tasks and 1000 tasks.

Table 1. Execution time of GWO, FPA, and PSO in milliseconds

No of tasks	GWO	FPA	PSO
200	120.2	142.1	144.4
400	125.3	153.6	157.6
600	130.1	157.8	162.7
800	140.5	168.9	174.2
1000	160.6	177.7	186.3

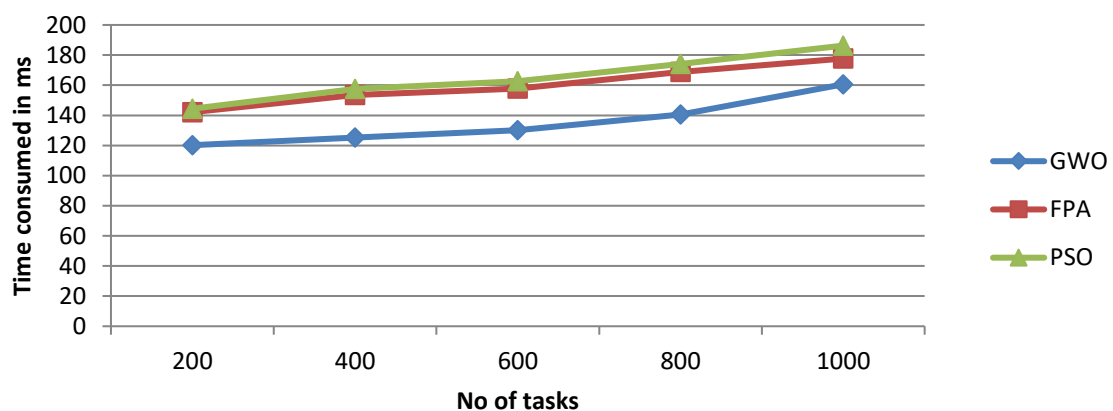


Figure 2. Execution time of GWO, FPA, and PSO in milliseconds

Table 2. Cost of GWO, FPA, and PSO in Rs

No of tasks	GWO	FPA	PSO
200	121.2	134.5	154.2
400	126.3	138.3	158.3
600	131.6	142.6	164.3
800	140.2	147.6	220.4
1000	150.6	162.5	235.4

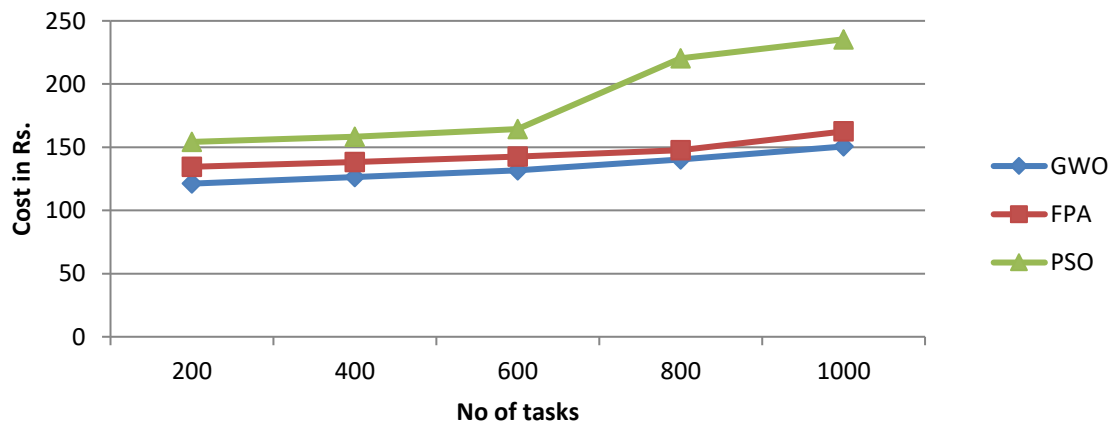


Figure 3. Cost of GWO, FPA, and PSO

5. CONCLUSION

The practice of dividing up available cloud resources among several users in accordance with a timetable that has been prepared in advance is referred to as scheduling. It is not feasible to achieve an adequate level of performance in settings that are dispersed if sufficient planning for concurrent processes has not been done. In order to construct effective schedules in the cloud, it is required for work scheduling to take into account a number of different limitations and objectives. A problem that is NP-hard is one in which finding a solution to it using the resources that are at one's disposal is very difficult. As long as this problem is not addressed, relying on the cloud for one's computing needs cannot be considered a successful strategy. When dealing with endeavors that have constraints on how well they can be optimized for performance, resource allocation is a highly crucial factor to take into consideration. When it comes to cloud computing, having an excellent task scheduling system is the only way to get amazing performance, high profitability, high scalability, efficient provisioning, and cost savings. In order to effectively offer a paradigm for properly scheduling work in a cloud computing environment, this article makes use of three different algorithms: the grey wolf algorithm, the PSO, and the FPA. If you use the job scheduling tool that is provided by GWO, you have the potential to get better results while spending less time and money on the endeavor.

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AUTHOR CONTRIBUTIONS STATEMENT

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C : **C**onceptualization

M : **M**ethodology

So : **S**oftware

Va : **V**alidation

Fo : **F**ormal analysis

I : **I**nvestigation

R : **R**esources

D : **D**ata Curation

O : Writing -**O**riginal Draft

E : Writing - Review & **E**ding

Vi : **V**isualization

Su : **S**upervision

P : **P**roject administration

Fu : **F**unding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

Ethical approval was not required for this study, as it did not involve human or animal subjects.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

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